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[DATA RECONSTRUCTION METHOD AND SYSTEM EMPLOYING THE SAME]

DATA RECONSTRUCTION METHOD AND SYSTEM WHEREIN TIMING OF DATA RECONSTRUCTION IS CONTROLLED IN ACCORDANCE WITH CONDITIONS WHEN A FAILURE OCCURS

now U.S. Patent No. 5,941,993,

now U.S. Patent No. 5,889,938,

CROSS-REFERENCES TO RELATED APPLICATIONS

This is a continuation of application Serial No. 08/895,886 filed on July 17, 1997, which is a continuation of application Serial No. 08/534,841 filed on September 27, 1995, which is a continuation of application Serial No. 07/859,850 filed on March 30, 1992, now U.S. Patent No. 5,495,572,

BACKGROUND OF THE INVENTION

The present invention relates to a memory for performing access or read/write in parallel with a plurality of independent storage units as a set, and more particularly to a data reconstruction system and a method used therein which are available in occurrence of a failure.

The technology for controlling discs arranged in parallel is disclosed in JP-A-H1-250128 ~~corresponds~~ corresponding to U.S. Patent Application Serial No. 118,785 filed on November 6, 1987, and JP-A-H2-135555.

As for the technology for achieving the large capacity of a memory and the high speed transfer of data, there is known a method in which the data is ~~striped~~ divided into a plurality of data of bit ~~unit, byte unit~~ units, byte units or arbitrary ~~unit~~ units, with a plurality of storage units as a set, to be stored in the respective storage units, and when the data is to be read out, the plurality of data is simultaneously read out from the respective storage units. Moreover, in this method, the data to be used for a parity check is produced from the data ~~striped up~~ divided among the storage units to be stored in another storage unit. When the failure occurs in any of the storage units, the data stored in the remaining normal storage units and the data for the parity check are used to

in parallel is disclosed in Japanese Kokai 1-250128 corresponding to U.S. Patent Application Serial No. 07/118,785 filed on November 6, 1987, now U.S. Patent No. 4,870,643, and Japanese Kokai 2-135555.

reconstruct the faulty data, thereby to improve the reliability of the memory.

Further, there is known the technology in which when the failure occurs in any of the storage units, not only the data is reconstructed for the normal read operation, but also the data stored in the storage unit at fault is reconstructed to be stored in the normal storage unit which is additionally provided. With this technology, the reconstructed data is stored in the spare storage unit and the data is read out from the spare storage unit for the subsequent access, whereby it is possible to improve the availability of the memory.

The failure of a certain number of storage units can be repaired by providing the parity data, and the data can also be reconstructed by the provision of the spare storage unit. However, for the operation of repairing the failure, it is necessary to read out all of the data stored in the normal storage units and the data for the parity check, reconstruct the faulty data and write the reconstructed data to the spare storage unit. Therefore, during the repair of the failure, the storage units are occupied so that the request to process the normal access or read/write which is issued from a host unit continues to wait. This results in the degradation of the performance of the memory. As for the error check method for reconstructing the faulty

data, there are known the parity data, the Reed-Solomon code and error check code (ECC) methods. Code and the error check code (ECC).

Although the redundancy is provided for the failure of a plurality of storage units, the failure repair in the failure of one storage unit and that in the failure of a plurality of storage units are managed without taking the distinction therebetween into consideration. Therefore, putting emphasis on the repair of the failure, since the processing of the normal access or read/write cannot be performed in spite inspite of the failure of one storage unit, there arises a problem in that the efficiency of the processing of the normal access or read/write is reduced. On the other hand, putting emphasis on the normal access or read/write operation, there arises a problem in that the time required for the repair of the failure is not secure during the failure of a plurality of storage units, and as a result, the possibility that the whole system may break down will be increased.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to minimize the reduction of the processing of the normal access or read/write in the failure, limit the time required for the repair of the failure within a fixed period of time, and ensure the high reliability, with respect to a memory which has the redundancy for the failure of two or more storage units.

It is another object of the present invention to provide a data reconstruction system which is capable of selecting a suitable data reconstruction method in correspondence to the various kinds of conditions relating to the repair of the failure and carrying out the most suitable data reconstruction processing.

It is still another object of the present invention to provide a control system which is capable of changing the procedure of data reconstruction processing in correspondence to the change of redundancy relating to the number of ECC discs included in a plurality of storage units which are arranged in parallel to one another.

The above objects of the present invention are attained by the provision of a memory including [comprising:] a group of storage units for dividing [striping] data into a plurality of data of bit units, byte units [unit, bite unit] or arbitrary units [unit] to store therein the divided [striped] data, the plurality of independent storage units forming a set; discs for storing therein ECC data corresponding to the divided [striped] data; a spare storage unit for storing therein the reconstructed data; an I/O-reconstruction control circuit for receiving a command relating to an I/O operation [I/O] issued from a host unit to execute processing in accordance with the command or respond to the host unit; a timer for giving the point of failure, an elapsed time during the data reconstruction, a unit time and the like; a data reconstructing table for the storage unit at fault;

and a faulty data reconstructing circuit for performing discovery of the faulty data, data reconstruction and an operation of writing data to a spare storage disc, wherein when a failure occurs in any of the storage units, the faulty data reconstructing circuit detects the failure by an error check to inform the I/O-reconstruction control circuit of the failure, and the I/O-reconstruction control circuit discriminates a state of the failure to select the preferred processing suitable for the state of the failure out of the processing of the normal access or read/write and the data reconstruction processing, thereby to execute the selected processing, or set the frequency of the processing of the normal access or read/write and the data reconstruction, or the ratio of the [processing] amount of the data reconstruction within a unit time. [amount.]

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When the failure occurs in the above memory, the redundancy of the memory, the elapsed time during the data reconstruction, and the state of the normal access or read/write processing and the like are discriminated, and the data reconstruction processing (method) suitable therefor is selected. Therefore, it is possible to prevent reduction of the performance of the processing of the normal access or read/write and ensure the high reliability of the memory. More specifically, in the case where the number of storage units at fault [has a room for] is less than the redundancy of the memory, there is selected the data reconstruction

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processing (method) in which the processing of the normal access or read/write is given preference, and the faulty data is reconstructed within the remaining period of time. Therefore, no load is put on the processing of the normal access or read/write. On the other hand, in the case where there is no remaining room in the redundancy, since the processing of reconstructing faulty data is given preference, it is possible to ensure the reliability for the failure of the memory. Moreover, in the case where there is some remaining a room in the redundancy, since the data reconstruction processing (method) is changed according to the magnitude of the accumulating totals of time which was taken to repair the failure with respect to the storage units in which the failure occurred, it is possible to prevent reduction of the performance of the processing of the normal access or read/write and limit the time required for the data reconstruction within a fixed period of time. Moreover, a the time zone, e.g., the night, having less processing of the normal access or read/write is selected so that the system can devote itself to the data reconstruction. As a result, it is possible to reduce the load of the memory in a the time zone having much processing of the normal access or read/write. Moreover, since the frequency of the data reconstruction processing, or the ratio of the amount of data reconstruction within a unit time, is set according to the magnitude of the frequency of the processing of the normal access or

read/write, it is possible to carry out the data reconstruction processing effectively in a time aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flow chart of the processing of reconstructing faulty data according to the present invention;

Fig. 2 is a block diagram showing the arrangement of a memory according to the present invention;

Fig. 3 is a diagram showing the arrangement of a data reconstructing table for a disc at fault of the present invention;

Fig. 4 is a flow chart showing the processing employed in the memory of Fig. 2;

Fig. 5 is a flow chart of a block of selecting the data reconstruction processing in Fig. 4;

Fig. 6 is another flow chart of a block of selecting the data reconstruction processing in Fig. 4;

Fig. 7 is still another flow chart of a block of selecting the data reconstruction processing in Fig. 4;

Fig. 8 is yet another flow chart of a block of selecting the data reconstruction processing in Fig. 4; and

Fig. 9 is a further flow chart of a block of selecting the data reconstruction processing in Fig. 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The description will hereinafter be given to a flow chart showing the processing of reconstructing faulty data of Fig. 1.

It is assumed that a failure occurs in a memory or a motor (Step 10). In this connection, this failure is detected by the check of an error check code or by the check of the deviation of a motor driving voltage from a predetermined range. First, it is judged whether or not the failure thus occurred is repairable (Step 20). If not, then, the data reconstruction processing is completed. This results in the data loss (Step 30). If so, it is judged on the basis of the redundancy of the memory, the elapsed time of the data reconstruction and the processing state of the processing of the normal access or read/write whether or not it is a state in which the system should devote itself to the data reconstruction (Step 40). If a request to process the normal processing such as access or read/write is issued from a host unit under the condition in which there is a sufficient remaining redundancy room and the urgency of the reconstruction is low, the data reconstruction processing is stopped and the normal processing such as access or read/write is given preference. Then, the data reconstruction processing is performed within the remaining period of time, and the processing of access or read/write during the data reconstruction is cancelled or queued (Step 50).

Conversely, if there is no room [remaining redundancy] and the urgency of the reconstruction is high, the data reconstruction processing is given preference, and all of the normal processing such as access or read/write is cancelled or queued (Step 60). Moreover, in the case of the intermediate state in which there are some combinations between the urgency of the data reconstruction and the significance of the normal processing such as access or read/write, the data reconstruction processing corresponding to the individual conditions is previously prepared in the form of programs. Then, when the conditions are changed, it can proceed to the [a] suitable processing [can be performed] by replacing an old program with a new one (Step 70). Next, when the data reconstruction processing is completed or interrupted, it is checked whether or not the data reconstruction processing still remains (Step 80). After all of the data reconstruction processing has been completed, the memory returns to the normal state. [state (Step 90).] If the data reconstruction processing still remains, the flow returns to Step 20 and the above Steps [step] will be repeated until the data reconstruction is completed.

Next, the description will be given to a block diagram showing the arrangement of an embodiment of the present invention of [will be described with reference to] Fig. 2.

In Fig. 2, the reference numeral 150 designates an I/O-reconstruction control circuit which receives a command relating to I/O [an I/O operation] issued from the host

unit to carry out the processing according to the command or respond to the host unit. Further, when a ~~the~~ failure ~~is occurring~~ has occurred in any of the storage units, the circuit 150 serves to select a suitable data reconstruction method on the basis of the number of discs during the reconstruction, the time taken to reconstruct the faulty data, the frequency of the data reconstruction, or the amount of the data ~~reconstruction,~~ reconstruction within a unit time, and the like. There is connected to the individual storage units a monitor 155 which monitors ~~that~~ whether after the power source for driving the storage units is activated, the driving voltage is in a predetermined range, and feeds a pseudo-instruction for reading out ~~the~~ data previously stored in a predetermined location to the storage units which are entering ~~getting~~ ~~into~~ the running state ~~to monitor~~ and monitors the responses sent therefrom. The reference numeral 154 designates a data reconstructing table for the storage unit at fault of which details will be described below with respect ~~on referring~~ to Fig. 3. The reference numeral 152 designates a clock or timer for obtaining the point of failure by giving the time of day and obtaining the elapsed time during the reconstruction and the unit time by a certain method. Then, the data reconstruction method can be changed based on ~~with~~ the time measured by the timer as one condition. The reference numeral 156 designates a circuit for reconstructing faulty data which performs the discovery of the faulty data, the data reconstruction and the writing ~~write~~ of the data to a spare storage disc. Moreover, the

circuit 156 reads out the data from all of the discs except the disc at fault, reconstructs the faulty data using the data thus read out, and transfers the reconstructed data to the host unit and writes it to the spare storage disc. The reference numerals 158, 160, 162, 164, 166, and ~~158 to~~ 168 designate a group of data discs for storing therein the divided ~~striped~~ data. Although six data ~~the six~~ discs are shown ~~as the data discs~~ in Fig. 2, the number thereof is generally arbitrary. The reference numerals 170 and 172 designate discs which store therein ~~the~~ ECC data corresponding to the divided ~~striped six~~ data which is stored in six data discs 158, 160, 162, 164, 166, and ~~the discs 158 to~~ 168. When the failure occurs, the faulty data is reconstructed using the ECC data and the normal data among the divided data stored in the six data discs 158, 160, 162, 164, 166, and 168. ~~data 158 to 168.~~ In this connection, the redundancy of the memory ~~which the memory has~~ corresponds to the number of ECC discs with respect to the number of discs up to a certain number. But, in the case where more than a certain number of the discs break down, ~~the discs break down of which number is more than that certain number,~~ it is impossible to reconstruct the faulty data. This results in ~~the~~ data loss. ~~Fig. 2~~ shows that ~~even~~ when the number of ECC discs ~~data~~ is two, when ~~i.e., the~~ two data discs break down, the faulty data can be reconstructed. However, since there is generally known an ~~the~~ ECC production method which can compensate for ~~stands up to~~ the failure of two or more discs, the number of faulty discs which does not result in ~~the~~ data loss, i.e., the redundancy can be increased. The ECC production is concretely realized using the Reed-Solomon code. ~~Code.~~ The

Reed-Solomon ~~Code~~ code and the error correction method employing the same themselves are well known. The reference numerals 174 and 176 designate spare storage ~~units~~ discs for storing therein the reconstructed data. Then, in the case where the storage contents of the faulty disc are stored in ~~the~~ a spare storage ~~unit,~~ disc, that spare storage ~~unit~~ disc is accessed with the data stored therein after the next time. The number of ~~those discs~~ spare storage discs is generally arbitrary.

~~The description will now be given to the~~ data reconstructing table for the disc at ~~fault.~~ fault will now be described with reference to Fig. 3.

The data reconstructing table 154 includes the identification number of the spare storage disc (1), the identification number of the disc at fault (2), the point of failure (3), the sector or address of the ~~faulty data~~ failure (4), and the flag used to judge whether or not the failure is repairable (5).

Next, the operations of the memory of Fig. 2 and the table of Fig. 3 will be described on the basis of a flow chart shown in Fig. 4.

First, in Fig. 2, it is assumed that the failure occurs in the data disc ~~unit~~ 162 (Step 100). Then, the circuit 156 for reconstructing faulty data detects that failure ~~to inform~~ and informs the I/O-reconstruction control circuit 150 of that failure. After receiving that information from the circuit 156, the circuit 150 checks whether or not an unoccupied space is present in the data reconstructing table 154 by referring to the

table 154 (Step 102). Subsequently, the circuit 150 checks whether or not that failure is a failure which occurred in a new disc (Step 104). If so, the circuit 150 instructs the circuit 156 to write the following initial values ~~to~~ in the columns of interest in the data reconstructing table 154 of Fig. 3. That is, the circuit 156 writes the identification number SPARE 1 of the spare disc 174 ~~to~~ in the column of the spare storage unit in the data reconstructing table 154, and writes the identification number #2 of the data disc 162 at fault ~~to~~ in the column of the storage unit at fault. Next, the circuit 156 writes the point of failure read out from the timer 152 ~~to~~ in the column of the point of failure, and writes the failure occurrence address in the faulty disc 162 ~~to~~ in the column of a ~~address.~~ ~~the~~ sector or address of the failure, Finally, the circuit 156 initializes the reconstruction judgement flag of each address (Step 106). If that failure is not a new one, the processing of Step 106 is not executed, but the processing proceeds to the subsequent ~~Step.~~ step. In the subsequent ~~Step,~~ step, the circuit 150 discriminates the state of the failure, selects either the processing of the normal access or read/write, or the data reconstruction processing which is suitable for the state of the failure, and executes the selected processing (Step 108). The details of this Step 108 will be described ~~on referring~~ below with reference to Fig. 5 to Fig. 9. Next, when the data reconstruction processing is completed or interrupted, it is checked whether or not

the data reconstruction processing still remains (Step 110). When all of the data reconstruction processing is completed, the memory returns to the normal ~~state.~~ state (Step 112). When the data reconstruction processing still remains, the processing returns to Step 102, ~~then, the above Steps will be~~ and the above steps are repeated until all of the data reconstruction processing is completed. ~~Even if~~ When any data reconstruction method is chosen, the circuit 156 monitors the continuation or completion of the data reconstruction processing. In the case where ~~the~~ a subsequent failure occurs when the data reconstruction of interest has not yet been completed, the circuit 156 starts performing the processing in the same manner as described above (Step 102). Then, in the case where the number of faulty discs ~~of~~ for which data reconstruction ~~in~~ is not completed exceeds the redundancy of the memory, since the data reconstruction is impossible, the circuit 150 informs the host unit of ~~the~~ a data loss (Step 114). If the data reconstruction processing is completed, the unnecessary data in the data reconstructing table 154 is erased and the memory returns to the normal state (Step 112). The address in the table 154 may ~~have~~ be in a track ~~unit, a sector unit, a word unit or any unit.~~ units, sector units, word units, or any other units.

Next, ~~the description will be given to~~ Step 108 of Fig. 4 will be described with reference ~~on referring~~ to Fig. 5.

In Fig. 5, the I/O-reconstruction control circuit 150 counts the number of discs ~~of~~ for which data reconstruction ~~is not~~ has not been completed by referring to the data

reconstructing table 154, and compares the number of faulty discs with the a threshold (Step 120). If the number of faulty discs is less than or equal to the threshold which is previously set to a value less than or equal to the redundancy, the circuit 150 judges that some remaining there is a room in the redundancy, gives the processing of access or read/write preference, and performs the processing of reconstructing faulty data within the remaining period of time. All of the processing such as access or read/write during the reconstruction waits, i.e., it is cancelled or queued (Step 122). On the other hand, if the number of faulty discs is more than the threshold, the circuit 150 judges that there is no remaining redundancy the redundancy has no room, gives the data reconstruction processing preference, and cancels or queues all of the normal processing such as access or read/write (Step 124).

The reconstruction is performed on the basis of with a unit, such as 1 track, in which the repair and the storage are completed in for a relatively short period of time. After the completion of the reconstruction, the memory is opened for the normal processing. But, when the instruction of the processing of access or read/write is issued from the host unit during the reconstruction, the data reconstruction work is stopped immediately, and then the memory is opened for the processing of access or read/write. In the case where during the processing of access or read/write, the data which has not yet been reconstructed is read out, the faulty data is then

reconstructed using the ECC data and the normal data which was used when producing the ECC data, and the reconstructed data is sent to the host unit. At the same time, the reconstructed data is stored in the spare disc and the reconstruction judgement flag of the address column of interest in the data reconstructing table 154 is set to ~~the~~ indicate completion of the reconstruction. If this flag is set to ~~the~~ indicate completion of the reconstruction, the subsequent access to this data is performed with the spare disc. In the case of ~~write of~~ writing data, after the ECC data has been produced, the data ~~to~~ which would normally be stored in the faulty disc is stored in the spare disc, and then the reconstruction judgement flag is set to ~~the~~ indicate completion of the reconstruction.

Since in the example of Fig. 2, the redundancy is two, it is proper that the threshold is necessarily set to 1. However, in the case where the Reed-Solomon ~~Code~~ code capable of correcting ~~the multiplex dissipation with~~ errors in two or more discs is used, the threshold may ~~have~~ be an arbitrary ~~Integral~~ integer number less than or equal to the redundancy. Those values are previously set in the table 157.

Since the I/O-reconstruction control circuit 150 stores the address of the last data which was reconstructed~~, at the last time,~~ the data reconstruction is ~~performed~~ continued from the subsequent address. In the reconstruction, the address of the last data which was reconstructed ~~at the last time~~ and previously stored is used. Then,

when the flag is not set in the data reconstructing table ~~154 and thus~~ 154, thus indicating that the data reconstruction is not completed with respect to the subsequent address, the data ~~of~~ at that address is reconstructed. The reconstruction of the data is performed in such a way that the ECC data and the normal data which was used to produce the ECC data from the normal discs are read out and the circuit 156 for reconstructing faulty data is used. The reconstructed data is written ~~to~~ in the spare disc and the flag in the data reconstructing table 154 is set to indicate ~~the~~ completion of the data reconstruction. Then, the reconstructed data in the spare disc ~~will~~ can be accessed. The address of the reconstructed data is stored in the circuit 156, and the processing by the circuit 150 proceeds to the subsequent data reconstruction processing.

In the embodiment of Fig. 5, when the number of faulty discs is less than or equal to the threshold, the processing of the normal access or read/write takes precedence over the data reconstruction. Therefore, it is possible to reduce degradation of the performance of access or read/write of the memory. Moreover, since in a state in which the system devotes itself to the data reconstruction, the reconstruction can be performed ~~for the~~ in a short period of time, it is possible to maintain the reliability of the memory.

In the above embodiments, the data reconstruction method is selected by paying attention to only the

number of faulty discs. However, the elapsed time taken to reconstruct the faulty data Can, can be, in addition to the number of faulty discs, be included in the conditions.

Next, another example of the description will be given to Step 108 of Fig. 4 will be described with reference on referring to Fig. 6.

In Fig. 6, the I/O-reconstruction control circuit 150 counts the number of discs for of which reconstruction is not yet completed by referring to the data reconstructing table 154, and compares the number of faulty discs with a the threshold (Step 130). If that number is less than or equal to the threshold, then, the circuit 150 reads the present time from the timer 152, and compares the time taken to reconstruct the faulty data, which can be calculated from the present time and the point of failure in the data reconstructing table 154, with a predetermined limit time (Step 132). Then, if the reconstruction time is less than the predetermined limit time, it is considered that there is a room for the data reconstruction can be deferred. reconstruction. Therefore, the circuit 150 instructs the circuit 156 for reconstructing faulty data to give the processing of the normal access or read/write preference, reconstruct the data in the faulty discs within the remaining period of time, and store the reconstructed data in the spare disc. The request to perform the processing of access or read/write issued from the host unit during the reconstruction is cancelled or queued (Step 134). If the number of faulty discs is more than the threshold, or the difference

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t failure → t present
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reconstruction time is

between the present time and the point of failure is more than the predetermined limit time, it is considered

can? or can not? that the data reconstruction cannot be deferred.

that there is no room for the data reconstruction. Therefore, the circuit 150 cancels or queues the command of the normal access or read/write issued from the host unit and instructs the circuit 156 to give the data reconstruction preference (Step 136).

In the embodiment of Fig. 6, when the time taken to reconstruct the faulty data exceeds the limit time, the system devotes itself to the processing of reconstructing faulty data. Therefore, it is possible to limit the reconstruction time within the (a) fixed period of time and improve the reliability of the memory.

another example of

Next, the description will be given to Step 108 of Fig. 4 on referring to Fig. 7.

will be described with reference

In Fig. 7, the I/O-reconstruction control circuit 150 obtains the present time from the timer 152 and judges whether or not that time is (in) a time zone having much processing of the normal access or read/write (Step 140). If not, the circuit 150 cancels or queues the command of the normal access or read/write issued from the host unit, and instructs the circuit 156 for reconstructing faulty data to give the data reconstruction preference. Moreover, even if that time is

in a time zone having much processing of the normal access or read/write,

the time zone, when the number of faulty discs of Step 142 exceeds the threshold, similarly, the data reconstruction processing is given preference (Step 146).

time is in a / having

Only when that time zone has much processing of the

normal access or read/write and the number of faulty discs is less than or equal to the threshold, is the processing of the normal access or read/write [is] given preference and the data reconstruction [is] performed within [for] the remaining period of time (Step 144).

In the embodiment of Fig. 7, when it is previously known that the method of using the memory depends on the time zone, the data reconstruction processing can be assigned to the time zone having less processing of access or read/write. Therefore, the data reconstruction processing can be smoothly carried out without the processing of access or read/write hindering the data reconstruction processing.

In the above-mentioned examples [embodiments] of Fig. 5 to Fig. 7, there are provided two kinds of data reconstruction processing in which the reconstruction or the processing of access or read/write is given preference. However, the kind of data reconstruction processing may be increased in correspondence to the circumstances.

Next, another example of [the description will be given to] Step 108 of Fig. 4 will be described with reference [on referring] to Fig. 8.

In Fig. 8, when the number of faulty discs exceeds the threshold in Step 180, the data reconstruction processing is given preference and the processing of the normal access or read/write is stopped (Step 188). When the number of faulty discs is less than or equal to the threshold, and the time is not in [it is not] the time zone having much processing of the normal access or

read/write in Step 182, only the read processing is performed and the data reconstruction processing is given preference for the remaining period of time (Step 186). When the number of faulty discs is less than or equal to the threshold and the time is in [it is] the time zone having much processing of the normal access or read/write, the processing of the normal access or read/write is given preference and the data reconstruction processing is performed within the remaining period of time (Step 184).

In the embodiment of Fig. 8, when the number of faulty discs is less than or equal to the threshold, but the time is in [it is] the time zone having less processing of the normal access or read/write, especially, the time zone having only the read processing, the read processing is preferentially [exceptionally] allowed to be performed, whereby it is possible to reduce degradation of the performance of the memory without hindering the data reconstruction processing.

Next, another example of: (the description will be given to) Step 108 of Fig. 4 will be described with reference (on referring) to Fig. 9.

In Fig. 9, when the number of faulty discs exceeds the threshold in Step 190, or the number of faulty discs is less than or equal to the threshold in Step 190 and the time taken to reconstruct the faulty data [accumulating totals of the data reconstruction time] exceeds the limit time in Step 192, the data reconstruction processing is given preference and the processing of the normal access or read/write is

stopped (Step 202). When the number of faulty discs is less than or equal to the threshold and the ~~accumulating totals of the data reconstruction time~~ time taken to reconstruct the faulty data is less than the limit time, the I/O-reconstruction control circuit 150 reads ~~the~~ a unit time from the timer 152, and compares the frequency of the processing of the normal access or read/write within that unit time with ~~the~~ a predetermined threshold (Step 194). When the frequency of the processing of the normal access or read/write is more than the threshold, it is considered that ~~the accumulation is within the limit time and there is a room for~~ the data reconstruction can be deferred. ~~reconstruction.~~ Therefore, the processing of the normal access or read/write is given preference and the data reconstruction processing is performed within the remaining period of time (Step 196). On the other hand, when the frequency of the processing of the normal access or read/write is less than the threshold, ~~and~~ the frequency thereof ~~is limitlessly~~ may have any magnitude near or far from the threshold, and thus the frequency changes in magnitude. Therefore, the frequency of the data reconstruction processing or the ratio of the amount of the data reconstruction within the unit time is dynamically set according to the magnitude of the frequency of the processing of the normal access or read/write (Step 198). Then, the data reconstruction processing is carried out according to the frequency of the data reconstruction processing or the ratio of the amount of the data reconstruction within the unit time thus set (Step 200).

In the embodiment of Fig. 9, the frequency of the data reconstruction processing or the ratio of the amount of the data reconstruction within the unit time is set according to the magnitude of the frequency of the processing of the normal access or read/write. Therefore, the data reconstruction processing ~~will~~ can be carried out effectively in a time aspect.

Although ~~the~~ a magnetic disc is ~~given~~ used as the storage unit in the above-mentioned embodiments, the present invention is not limited thereto or thereby. That is, alternatively, an optical disc, a floppy disc, or a semiconductor memory may be used as the storage unit.

Moreover, as the conditions for selecting the data reconstruction method, instead of the above embodiments, the job contents of the host unit, the significance of the file in the memory, and the like may be used as the conditions. The combination of those conditions and the data reconstruction method allows the flexible data reconstruction processing to be performed.

According to the above embodiments, when the number of storage units at fault is less than the redundancy of the memory, the processing of access or read/write takes precedence over the data reconstruction processing. Therefore, the load of the memory is not increased so that it is possible to reduce degradation of the response performance of the memory in the processing of access or read/write to the utmost.

Moreover, since when a room the remaining of the a redundancy becomes small, the processing of access or read/write is automatically stopped and the data reconstruction processing is given preference, the reliability of the memory is not reduced. Further, since the data reconstruction processing method is changed according to the time taken to reconstruct the faulty data accumulating totals of the data reconstruction processing time of the storage units at fault, it is possible to realize the a memory of higher reliability. Moreover, since the frequency of the data reconstruction processing or the ratio of the amount of the data reconstruction within the unit time is set according to the magnitude of the frequency of the processing of access or read/write, it is possible to carry out the data reconstruction processing effectively in a time aspect.